Artificial Lifeguard

EC601 Project 1
Maolin Wei

1 Introduction

Drowning is a very significant problem in the world. According to the data from World Health Organization[1], drowning has caused about 236000 deaths every year and caused over 2.5 million deaths in the last decade. Drowning can happen in rivers, public pools, indoor swimming pools and so on. Not every place could have professional lifeguards. Even for the places with professional lifeguards such as swimming pools and beaches, drowning is still a leading cause of death. Since human lifeguards are unable to maintain a high level of alertness at all times, and it is difficult for them to see a drowning person timely in a large and crowded pool or beach. Also, human lifeguards are unable to see a drowning person who is underwater. Therefore, it is very necessary and important to find effective solutions to detect and identify drowning people and provide timely assistance in order to reduce the number of drowning deaths. One solution is to utilize artificial intelligent techniques to recognize drowning people, then send alert to human lifeguards or provide assistance directly.

Artificial intelligent lifeguard depends on videos and algorithms. By using cameras to monitor people at swimming pools, beaches and so on, the AI lifeguard can process input videos captured by the cameras and recognize people who may be drowning. There are several advantages using AI lifeguard. First, AI lifeguard can work at all times and never need a break. Second, the cameras can be installed underwater at the swimming pools, so the AI lifeguard is able to detect drowning people underwater, which is difficult for human lifeguards to do so. Third, AI lifeguard can keep an eye on every person in view of the cameras, but human lifeguards cannot do it. Finally, cameras and algorithms can be combined with other techniques such as robotics to develop autonomous rescue products to protect people from drowning.

2 Latest Research Areas

2.1 Sensor System

The sensor system is to use multiple sensors to detect drowning. These sensors usually include water flow sensors, buoys and buoyancy sensors, sound sensors and so on to monitor conditions in the water and send alert signals or provide assistance when people need help. People could carry the equipment building with several sensors into

[1] https://www.who.int/campaigns/world-drowning-prevention-day/2023

the water. Kulkarni et al. [1] devised a system consisting of three sensors: a non-invasive oxygen saturation level sensor, respiration monitoring sensor and water sensor that were used for detecting parameters like blood oxygen saturation levels, respiratory movements and submersion of a person's body underwater respectively, and a controller for monitoring, processing and controlling purposes. If any two of the above-mentioned parameters detect drowning, the system detects it as a case of drowning. Hariharan et al. [2] introduced WiEyeTNB, a smart sensor product consisting of a microprocessor, RF transceiver, one or more sensors and powering devices for detecting drowning. The system issues an alarm through a wireless network so that immediate attention can be given to the casualty.

2.2 Advanced Machine Learning Algorithms

Recently, a lot of approaches [3, 4, 5, 6, 7, 8, 9, 10] are proposed for people drowning detection based on image and video processing and machine learning techniques. A drowning person won't be able to breathe or call loudly for help since the head will be submerged in the water. Also, human lifeguards cannot able to see underwater situations. However, by using overwater and underwater cameras, the drowning person can be located timely so that professional lifeguards can go to provide assistance. Jian et al. [3] proposed using postures of drowning people for drowning detection. By using OpenPose [4] to mark the image joint point features, and input the captured joint point features into the recursive neural network to determine whether the swimmer is drowning. He et al. [6] explored YOLOv5 and Faster RCNN algorithms for infants drowning detection.

2.3 Autonomous Rescue Robots

Autonomous rescue robots are designed to protect people from drowning. These robots are usually equipped with cameras, computing hardware, software system and rescue equipment such as lifebuoys. They can detect drowning people based on its embedded visual perceptual systems. Also, they have the capability of autonomous navigation. When someone is detected drowning by them, they will move rapidly to provide assistance. In the meantime, they will send signals to base station or rescue people. Yang [5] et al. proposed a drowning detection algorithm for intelligent lifebuoy robot. They designed an improved YOLOv4 network to detect the drowning person and a geometric distance measurement method based on the bounding box to detect the position.

3 Review of "A Water Behavior Dataset for an Image-Based Drowning Solution" by Hasan et al. [7]

This paper proposed a water behavior dataset including three major water activity behaviors (swim, drown, idle) that have been captured by overhead and underwater cameras and developed two deep learning methods to test using proposed dataset.

To be specific, they used overhead and underwater cameras to collect the images of different behaviors including swimming, drowning and staying idle for every person to build the dataset. The swimming behaviors are people swim normally, the drowning behaviors may include waving with arms, having heads submerged in water, etc. The idle behaviors are that people stay idle in the water with heads are over water. To test the proposed dataset, the authors used Resnet50, VGG16 and MobileNet to do scene classification and HRNet architecture to do pose estimation for drowning detection with evaluation metrics of F1-Score, precision and recall.

The conclusion for this paper is that both scene classification and pose estimation methods are efficient at recognizing each of the water behavior activities with their proposed dataset, but the pose estimation method slightly outperformed the scene classification method, knowing that the former depended less on the scene variations.

4 Future Steps to Work on the Topic

4.1 Target User/Application

First of all, the target users could be the professional human lifeguards and the management department of swimming pools. The management department could install multiple overwater and underwater cameras to capture videos of the entire pool area. These videos will be sent to the computer server to detect and identify drowning people in real time. When people are detected drowning, it will send alerts and location to the professional lifeguards for assistance.

Additionally, for wearable devices, the target users could be the swimmers and the professional human lifeguards. Swimmers can carry the devices with them and get assistance when they need help. The professional human lifeguards can receive rescue signals when someone needs help.

4.2 Impact on Proposal

Based on above, to meet the requirements of practical application, the AI lifeguard need to have high accuracy in detecting drowning situations and fast detecting time. In addition, only a detection system is not enough, it is necessary to build a communication system that connects cameras, computer servers and professional lifeguards. For wearable devices, it is necessary to make sure that the device is work properly and can response rapidly, even under a terrible situation such as very rapid water.

4.3 The Future Steps

(1) Reading more relevant papers in this field to explore latest research areas and state-of-the-art detection algorithms. After that, I will have clearer insights about what directions I should to continue to conduct my research on, how to improve the detection performance, and how to get the data.
(2) Collecting and processing data. A lot of data is needed to train a deep learning networks, so collecting a large number of images and videos is very important. With multiple data from different environments, the deep learning models will be more accurate, robust and generalized. The collected data also needs to be processed and well-labeled so that the supervised learning algorithms can work with.
(3) Figuring out how to connect cameras, computer servers and professional lifeguards. The servers should receive input videos captured from the cameras and process the videos in real time. Once someone is detected drowning, the professional lifeguards must know immediately. There are two ways to achieve it. One is someone, who is in the monitoring room to monitor the videos captured by the cameras, uses walkie talkie or cellphone to communicate the drowning person's location to professional lifeguards. Another way is the professional lifeguards could get the alert and location by wearable devices or mobile app, which may be more effective.
(4) Developing the systems and testing. When I have a specific idea, I could start to build the systems, including detection system and communication system. Once the entire system is built, it needs to be test in the practical situations such as an indoor swimming pool. Then trying to optimize it according to the testing results.
(5) Putting into practical use. When the testing results is favorable, the system can be packaged as a real product for practical use. By collecting the feedback from the users, the product can continue to be optimized.
(6) Exploring more applications. When the product could work stably, I could work on exploring more application such as detecting drowning in open water environments. These environments may not have professional lifeguards, and maybe the water is dirty, so the AI lifeguard needs to not only detect drowning people, but also provide assistance. Therefore, it will combine with robotics techniques to do it, and the target users may be the governments that want to prevent drowning accidents.

5 ChatGPT's Analysis

5.1 Latest Research Areas

(1) Enhanced Sensor Technologies: Researchers are continually improving sensor technologies for better data collection. Advanced cameras, underwater sonar systems, and environmental sensors are being developed to provide real-time data on water conditions, swimmer movements, and potential hazards.
(2) Machine Learning and AI Algorithms: The application of machine learning and

artificial intelligence has become increasingly crucial in artificial lifeguard systems. These systems are being trained to recognize different swimmer behaviors, such as distress signals or signs of fatigue, and make predictions about potential drownings.

(3) Robotics Integration: There is growing interest in combining autonomous underwater vehicles (AUVs) and drones with lifeguard systems. These robots can quickly reach swimmers in distress, provide flotation devices, and communicate with human lifeguards.

(4) Communication Systems: Developing efficient communication systems that can alert lifeguards and emergency responders in real-time is an essential area of research. This includes integrating wearable devices, mobile apps, and IoT (Internet of Things) technologies.

5.2 Future Steps to Work on the Topic

(1) Target Users/Applications: The primary target users for AI lifeguard systems are aquatic facilities, such as public swimming pools, water parks, and private pools. These systems aim to enhance pool safety by providing early detection and alerts for drowning incidents, ultimately reducing the risk of water-related accidents.

(2) Impact on Proposal: Given the potential life-saving impact of AI lifeguard systems, the proposal should emphasize the collaboration between researchers, industry stakeholders, and pool facilities. Additionally, it should prioritize addressing real-world challenges such as system integration, accuracy improvement, and ethical considerations. The proposal should also outline a plan for usability testing with lifeguard teams to ensure that the technology effectively supports their roles.

5.3 The Future Steps

(1) Real-time Implementation and Integration: One of the most critical steps forward would be to implement and integrate these AI lifeguard systems in real-world swimming pool environments. Collaborations with pool facilities and lifeguard teams would be essential to test the effectiveness of these systems in live scenarios. This would require addressing challenges such as camera placement, data transmission, and system reliability.

(2) Enhanced Pose Estimation: Further research can focus on improving the pose estimation method. This includes refining the accuracy of keypoint detection in varying water conditions, such as turbulence or low visibility. Additionally, extending the pose estimation to recognize distress signals from swimmers could be valuable.

(3) Multi-Camera Systems: Investigate the use of multi-camera systems, including underwater and above-water cameras, to provide a more comprehensive view of the

pool. This could involve developing algorithms for camera coordination and fusion to increase the system's ability to detect and respond to potential drowning incidents.

(4) Edge Computing and Low-Latency Processing: To ensure rapid response times, explore the feasibility of deploying edge computing capabilities to process data locally near the poolside. This would reduce the latency in identifying and responding to emergency situations.

(5) Ethical and Privacy Considerations: As these systems involve surveillance and data collection, it is crucial to address ethical and privacy concerns. Research should focus on implementing privacy-preserving measures and ensuring that data collected is used solely for safety purposes.

(6) Scalability and Affordability: Consider ways to make AI lifeguard systems accessible to a wide range of pool facilities, including smaller or community pools. This may involve developing cost-effective hardware and software solutions.

6 Reference

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